

Spin and Luminosity at RHIC

$$A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

Beam is not 100% polarized. We measure a combination of σ_+ and σ_- :

Counts (for 100% acceptance): $L^+ = L^- = L$ also use

$$C^+ = L_+^+ \sigma_+ + L_-^+ \sigma_- \quad (L = \int L' dt)$$

- for beam polarized in + direction

$$C^- = L_+^- \sigma_+ + L_-^- \sigma_-$$

- beam pol. in - direction

... algebra

$$A_L = \frac{1}{P_{\text{avg}}} \frac{C^+ - C^-}{(C^+ + C^-) - (C^+ - C^-) \frac{P_{\text{dif}}}{P_{\text{avg}}}}$$

$$P_{\text{dif}} = \frac{P^+ - P^-}{2}$$

$$P_{\text{avg}} = \frac{P^+ + P^-}{2}$$

$$P^+ = \frac{L_+^+ - L_-^+}{L_+^+ + L_-^+}$$

$$P^- = \frac{L_-^- - L_+^-}{L_-^- + L_+^-}$$

P^+ and P^- can be calculated from the polarisation of individual bunches:

$$P^+ = \frac{B_+^+ - B_-^+}{B_+^+ + B_-^+}$$

$$= \frac{\sum (B_{+i}^+ - B_{-i}^+)}{\sum (B_{+i}^+ + B_{-i}^+)}$$

B_+^+ = number of beam protons with pol = + for a + pol. signa bunch;
 $L_+^+ = \text{const.} \times B_+^+$

↑ sums over crossings for + polarized bunches

$$= \frac{\sum B_i P_i^+}{\sum B_i}$$

$$P_i^+ = \frac{B_{+i}^+ - B_{-i}^+}{B_{+i}^+ + B_{-i}^+}$$

$$P^+ = \frac{\sum L_i^+ P_i^+}{\sum L_i^+}$$

$$P^- = \frac{\sum L_i^- P_i^-}{\sum L_i^-}$$

P^+ and P^- are the weighted avg.s of the bunch polarizations, weighted by the luminosity of the crossings.

Case for $a = \text{acceptance} \neq 100\%$, $L^+ \neq L^-$:

$$C^+ = \frac{N^+}{a^+ L^+} \quad C^- = \frac{N^-}{a^- L^-}$$

$$A_L = \frac{1}{P_{\text{avg}}} \frac{C^+ - C^-}{(C^+ + C^-) - (C^+ - C^-) \frac{P_{\text{dif}}}{P_{\text{avg}}}}$$

For some signals (jets), $N = N^+ + N^- \approx 10^6$

$$\Rightarrow \Delta N / N \approx 10^{-3}$$

\Rightarrow need relative luminosity

$$\frac{\Delta L}{L} \approx 10^{-4}$$

\Rightarrow statistics for $\Sigma L \approx 10^8$
and want systematics for
measuring L to 10^{-4} .